Dr. Arthur Trembanis

NOAA NMFS
Center for Independent Experts (CIE) Program
External Independent Peer Review- Post Panel Meeting Review Report

Remotely Operated Vehicle (ROV) Surveys of Nearshore Stocks - California & Oregon

SWFSC Santa Cruz Laboratory- Site of February 2020 Review Panel

Executive Summary of Findings

At the request of the NOAA NMFS CIE Program, an independent technical peer review of the OR (ODFW) and CA (CDFW) ROV-based fish survey research programs was performed to evaluate the strengths and limits of photographic, videographic and integrated geoacoustic habitat mapping, as well as associated platforms and post processing of seafloor and water column images as part of the inshore fishery monitoring strategy. This follow-on to the initial review was conducted based on the updated reports and relevant publications and informed by additional comparison to previous and ongoing programs of similar design in other parts of the country. The review meeting focused on four major thematic topics: 1) generation of imagery data and field survey design; 2) data aggregation and habitat relationships; 3) analytical methods; and 4) future directions and utility to stock assessment. These topics were examined through a series of presentations by each team and discussion questions from the review panel and meeting attendees, and here in this report the assessment is addressed to specific terms of reference (ToR) provided to the reviewer. The overall findings are that both the OR and CA programs are utilizing sensors and platforms that are considered state of the art and employing best available practices with regards to sampling design and field survey execution. Areas for improvement and programmatic growth are identified that include working towards further coordination between states, and also states and federal (NOAA) teams in order to harmonize operations, and cataloging data into discoverable database structures. Another recommendation is to establish a list of suitable and non-suitable species that are/are not amenable to the ROV-based abundance and size estimation efforts. It is recommended to continue the combined approaches of both design-based and model-based approaches for upscaling survey estimates to larger spatial and temporal scales and to also use the model estimates to help guide subsequent sampling efforts. Going forward, it is recommended for OR to pursue segment level analysis working down in scale from full transects. Similarly, it is recommended for CA to explore summarizing analysis to full transect. In this way, each state will provide complementary harmonized approaches to support further comparison of results. As a general recommendation to both programs, every effort should be made to expand fish length measurements which are harder to come by and are important for converting

abundance to biomass estimates. Both individual counts and size measurements are recommended to be stored in a database format, so as to support the long-term goal of training and testing and then integrating available machine learning community tools for automated detection of targets within imagery and video into the survey programs. Additional short-term sampling recommendations are to include some sampling into sub-optimal habitat areas to establish some density measurements, and also to try and repeat at least one transect in every survey period to assess short-term variability. Both programs are to be commended for the efforts to conduct these survey programs often through leveraged grant and other project funds, and a long-term recommendation is for all states in the region together with federal fishery groups to seek partner funding for sustained and expanded sampling and support for the needed equipment and data storage improvements.

Background

The National Marine Fisheries Service (NMFS) and the Pacific Fishery Management Council (PFMC) are seeking a panel review to follow-up on the FY19 desk review to evaluate and review fishery independent visual survey methodologies, using remotely operated vehicles (ROVs), for nearshore Groundfish species off the states of Oregon and California.

West coast nearshore groundfish stock assessments have identified the current lack of fishery-independent data sources as a research and data need (PFMC, 2017, Agenda Item E.2, Attachment 1, September 2017). In addition, methods currently utilized in stock assessments do not explicitly account for differential biomass densities inside of no-take Marine Protected Areas (MPAs). Remotely operated vehicles (ROVs) provide a non-lethal sampling method in areas where harvest is prohibited. They also allow collection of data on overfished species and nearshore species that constrain take of healthy stocks. Because ROVs employ only non-lethal data collection methods, they avoid the need for research catch set-asides or other allocative considerations that may arise between fisheries and research sectors.

Both Oregon and California have conducted ROV surveys of rockfish in nearshore areas, focusing on rocky reef habitat, and, in California, on areas inside and outside of MPAs. In both states, resultant information includes density estimates (by transect and habitat) for various species and length data. In addition, the states have developed seafloor maps, allowing estimation of area of habitat types by depth and latitudinal breaks.

Density estimates can be developed in a number of ways, from simple extrapolations to more complex “design-based approach” general linear models (GLMs) and “model-based” generalized additive models (GAMs), including factors that may affect detection probability across sample sites. There is likely to be differential detection by species, gender and size, and by timing of survey as well.

Observed density estimates and indices of relative abundance or estimates of absolute abundance in the depth and latitudinal areas surveyed can be used in stock assessments, given appropriate accounting for selectivity and detection probability, or potentially used in

management procedures. Length composition data collected by the surveys may be included in stock assessments or management procedures as well.

The general goals and objectives of Council methodology reviews are to:

1) Ensure that research surveys, data collection, data analyses and other scientific techniques in support of coastal pelagic species (CPS) and groundfish stock assessments are the best available scientific information and facilitate the use of information by the Council;

2) Provide recommendations regarding whether, and if so, how a particular methodology can be applied in future stock assessments;

3) Meet the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (MSRA) and other legal requirements;

4) Follow a detailed calendar and fulfill explicit responsibilities for all participants to produce required outcomes and reports;

5) Provide an independent external review of survey and analytical methods used to develop data to inform CPS and groundfish stock assessments;

6) Increase understanding and acceptance of CPS and groundfish research methodologies and review by all members of the Council family;

7) Ensure that methodologies not directly related to stock assessments, such as economic analyses or ecosystem-based fishery management approaches, undergo adequate peer review, as appropriate; and

8) Identify research needed to improve assessments, reviews, surveys, analyses, and fishery management in the future.

The goals and objectives specific to the review of the California and Oregon ROV survey methodologies are to:

1) Evaluate the sampling design used in recent ROV surveys conducted by the states of Oregon and California.

2) Evaluate proposed methods to develop indices or estimates of abundance for these ROV surveys, including using habitat/substrate type and Marine Protected Area designation as covariates.

3) Evaluate proposed methods to estimate size compositions of observed individuals of each species.

4) Identify potential impediments to developing independent indices or estimates of abundance using these ROV surveys and incorporating them into stock assessments.

Problem Statement and Background

Human reliance upon and extraction from pelagic and benthic ecosystems necessitates an understanding of the spatial extent, structure, and function of these ecosystems. This report is a follow-on review of the California (CDFW) and Oregon (ODFW) West Coast ROV (Remotely Operated Vehicle) based programs engaged in using ROVs for remote benthic habitat mapping and fisheries studies. This review examined updated reports, panel presentations, and primary literature in order to assess the scope of the program activities from experimental design, field implementation, imagery post-processing and data analysis.

Digital photography/videography is rapidly becoming the de facto technology of choice to document macrofaunal seafloor habitats and demersal fish communities. The ability to record and inspect a large number of images while still in the field has made image sampling much more efficient, and allowed significantly larger sample sizes, when compared to the days of film. In addition, traditional sampling, using quantitative grabs and/or dredges, is still necessary to ground truth images with actual specimens, and sediment samples, but can be based on near real time inspection of imagery. In short, traditional grab sampling, by itself, is conducted on too small a scale, and requires too much extrapolation, to adequately characterize benthic

communities and habitats on the scale that would reflect climate change or on the scale required for the management of offshore development efforts.

Admittedly, visual imagery has its technical limitations, but the numbers of photographs, and consequently the amount of quantitative data that can be generated on a single cruise, far exceeds that of grab or dredge-based sampling. Indeed, one of the major issues facing the use of visual imagery for sampling is how best to deal with the resulting terabytes of available information. Although machine vision promises to automate the assessment of visual images, and is achieving success for single species such as scallops, the techniques are still in development and require more annotated image databases to create the necessary post processing tools for comprehensive survey of diverse marine fisheries communities.

Individual Reviewer's Role in Review Activities

The Individual Reviewer's Role in the Review Activities is to conduct an impartial and independent peer review in accordance with the PWS, OMB guidelines, and the ToRs below. The individual CIE reviewers were selected based on having a working knowledge in visual survey techniques, survey design and analysis, and familiarity with incorporating survey information in stock assessments and have conducted the previous desk review held in FY19. The present report is a follow-on to the FY19 desk review performed by the author based on the updated state reports and presentations made at the panel review meeting held at the SWFSC Santa Cruz Laboratory in February 2020.

Summary of Findings

The overall summary findings by this reviewer based on the updated reports and panel meeting deliberations are that both the OR and CA programs are utilizing sensors and platforms that are considered state of the art and employing best available practices with regards to sampling design and field survey execution. Areas for improvement and programmatic growth are identified that include- working towards further coordination between states, and also states

and federal (NOAA) teams, in order to harmonize operations and cataloging data into discoverable database structures. Another recommendation is to establish a list of suitable and non-suitable species that are/are not amenable to the ROV-based abundance and size estimation efforts. It is recommended to continue the combined approaches of both design-based and model-based approaches for upscaling survey estimates to larger spatial and temporal scales, and to also use the model estimates to help guide subsequent sampling efforts. Going forward it is recommended for OR to pursue segment level analysis working down in scale from full transects. Similarly, it is recommended for CA to explore summarizing analysis to full transect. In this way, each state will provide complementary harmonized approaches to support further comparison of results. As a general recommendation to both programs, every effort should be made to expand fish length measurements which are harder to come by and are important for converting abundance to biomass estimates. Both individual counts and size measurements are recommended to be stored in a database format so as to support the long-term goal of training and testing, and then integrating available machine learning community tools for automated detection of targets within imagery and video into the survey programs. Additional short-term sampling recommendations are to include some sampling into sub-optimal habitat areas to establish some density measurements, and also to try and repeat at least one transect in every survey period to assess short-term variability. Both programs are to be commended for the efforts to conduct these survey programs often through leveraged grant and other project funds, and a long-term recommendation is for all states in the region together with federal fishery groups to seek partner funding for sustained and expanded sampling, and support for the needed equipment and data storage improvements.

Terms of Reference (ToR)

ToR 1) **Become familiar with the reports describing the survey designs, data processing and analysis along with other pertinent information prior to review panel meeting:**

Review of ToR 1

This reviewer met the requirements of this ToR through various means including the reading of the revised reports, reviewing the slide presentations, attending and participating in the panel review meeting and taking notes and asking questions throughout the process. Notes were taken throughout the review panel meeting and questions raised by this reviewer and other panel members were addressed by the science teams during the meeting. Copies of presentations were conveyed to all the panel members for subsequent review.

ToR 2) **Discuss the technical merits and deficiencies of the survey designs and analytical methods during the open review panel meeting, including revisions based upon feedback from the desk review.**

Review of ToR 2

Survey Designs:

Technical Merits:

The following are highlights of technical merits associated with the survey designs of the reviewed programs.

Both programs have established strong track records of field survey efforts through multiple years of operations. The CA team is a larger group and the ROV operations are coordinated through MARE utilizing dedicated research vessels. The OR program is a smaller team and utilizes vessels of opportunity for ROV operations. In both cases, the programs have developed and implemented field protocols that have successfully been carried out over broad geographic domains.

Both programs utilize predominantly COTS ROV technology with modifications/upgrades made to camera and lighting systems, and again these are all considered to be sound and solid

systems, though admittedly there are end of useful life concerns and opportunities for sensor improvements that are discussed later in this report.

Additional Merits include the following:

- Both evaluated programs use similar approaches of 500 m long transects randomly selected within site locations.
- Both programs utilize USBL tracking for the ROV positioning.
- Both programs employ HD camera and underwater lighting along with sonar altimeters.

Deficiencies:

As with any field program there are strengths and weaknesses or areas for improvements. Regarding these so-called deficiencies (perhaps too strong of a term) the following considerations are offered by this reviewer. Relative to the habitat areas, the total number and distribution of sampling is small (a funding resource limitation), and thus there is no synoptic survey of the entire area and only sporadic temporal revisit of a few sites.

A potential impediment to the strength of the inferences that can be drawn from the ROV surveys stems from the challenges involved in establishing sufficiently large numbers of samples--conducting transect surveys requires extensive commitments of time and funding. The biggest thing that would benefit the program is an increase in the temporal and spatial coverage.

The available bathymetry and substrate classification maps do not fully cover the habitat range, leaving gaps near shore (the white zone) and offshore, which limits some of the areas that can be surveyed and requires interpolation for upscaling.

Positioning data from the USBL is noisy, requiring smoothing and averaging that introduces localization uncertainty. Also, controls over rough bottoms are such that there are bottom lock losses (height above bed) that translate into data holidays.

Analytical Methods:

Technical Merits:

The survey program data have undergone rigorous statistical treatment and utilize well recognized approaches to expansion of the species level data into habitat-based, MPA, and regional summaries incorporating a range of methods from simple aggregation to Generalized additive models (GAMs). In both survey programs that were examined (OR and CA), the operation teams have demonstrated a high quality of resulting scientific data. The following are highlights of technical merits associated with the analytical methods of the reviewed programs.

The analytical approach of both programs uses a combination of approaches for upscaling utilizing design-based (GLMs) and model-based (GAMs) for independent estimates of total abundance and then biomass comparison. This combined approach is seen as a strong positive analytical merit of the programs.

Both programs have also made strong and abundant usage of available mapping datasets for bathymetry and substrate classes and have used these datasets also to derive additional habitat relevant parameters (such as slope and BPI). The approach of using spatial mapping products to guide and inform both the survey design and analytical upscaling is seen as a strong and very positive technical attribute of these programs.

Updates to the reports based on the initial desktop review are noted in both the OR and CA program reports and are appreciated. These updates reflect careful consideration and responses to the desktop review comments from the other review panel and from the independent CIE expert reviews. I noted in particular that the OR report introduced some new data from 2018 and expanded the GAM modeling section and also introduced the VAST spatial modeling effort.

Deficiencies:

As with any analytical program there are areas of known or revealed weakness that provide opportunities for consideration and improvement. The following are considerations that this reviewer wishes to note.

It is known and acknowledged by the teams, but important always to keep in mind, that the portion of habitat being sampled is small and this presents a source of uncertainty, and emphasizes the need to expand the sampling in as much as funding support can be managed to increase efforts. One statistic that was shared in the review panel presentations was an estimate that <0.1% of the habitat for rock gopher down to about 70 m has been sampled and this helps provide a context to the challenges involved.

The use of Coastal Relief Model for depth inputs particularly to fill in white zone gaps near shore and offshore gaps is understood as a necessary gap filler but is a source of uncertainty and deficiency. Great caution and care should be taken with the use of CRM as it is a combination of many various data sources over different years, techniques, and datums. Teams are encouraged to consider and explore for bathy/topo LiDAR sources for nearshore data and to encourage state or federal agencies to assist with multibeam efforts to fill in offshore gaps where these are known.

Relatively low number of fish sized relative to abundance counts. Admittedly some of this is limited by viable fish images for sizing, but every effort should be made to expand the sizing, especially through the use of stereo camera

It seemed that from the review panel discussion, some analysis and scaling up was being done via post-stratification, which was a topic that received discussion. Dr. Stratton recommends avoiding post stratification as this leads to small sample sizes, and this reviewer supports and affirms this same recommendation. Rather, it is recommended to use the substrate information and establish stratified random sampling.

It was clear from the discussions and presentations that there are variations in what ground fish species are more amenable to the ROV-based imagery surveys versus others that are not owing to aspects of habitat and behavior. In the discussions, it was conveyed that kelp greenling, for instance, is a good candidate species as it is well distributed and well behaved but that Quillback is less ideal. A characteristic summary analytical product that is somewhat missing would be a table listing species that either are or are not well suited to these kinds of programs.

I recommend that there be an expansion and clear delineation of the suitability of known species of concern.

ToR 3) **Provide constructive suggestions for improvements.**

Review of ToR 3

Suggested Survey Improvements:

The following are recommendations for improvements to the survey portion of the programs.

Improve ROV navigation with combination of higher precision (less noisy) USBL plus suggest the addition of onboard DVL/INS and/or visual odometry to aid in positioning.

Suggest the increased use and implementation of stereo camera images for more fish sizing, and also can be used to provide in situ measurements of seabed roughness as a habitat metric of finer resolution than the available bathymetry.

Suggest making use of all camera and sonar sources. These data sources should at the least all be recorded and archived into secure, backed up, and discoverable databases for future testing. Downward looking camera can be used, for example, as another abundance source to the forward camera, and can aid in steep terrain areas where there is loss over the backside of large rock ledges. The downward looking cameras, if recorded with sufficient overlap, could further be used for photogrammetric stitching of the images into mosaics that would provide a useful basis for visual odometry and could be used to establish structure from motion as a further guide to bottom roughness. Sonar data can be used to expand the optical footprint and to provide further constraint on substrate, and also on terrain-based navigation.

Suggest that each program seek funding (perhaps in a regional collaboration) in order to expand the number of survey sites in proportion to available funding, particularly with the aims of sampling informed from the analytical models and with the goal of expanding sampling into sub-optimal habitat areas in order to confirm densities in those settings.

Suggest using model abundance upscaling as testable predictions for survey validation efforts.

Suggested Analytical Improvements:

The following are suggestions related to the analytical portion of the programs based on the review panel meeting presentations and discussions.

Suggest that for OR analysis be examined at segment level to provide some added spatial granularity to augment the existing transect level analysis.

Suggest that for CA to examine transect level analysis to augment the existing segment level and also at the segment level, not to discard small segments but rather to include them as well (a recommendation also that came up at the review meeting suggested by Dr. Shelton).

Suggest that seabed classifications from the mapping programs be compared and harmonized, and also that the ROV-derived substrate data be used as a direct test of the mapping derived substrates (a confusion matrix approach works well here) and that where there are areas of disagreement, that these findings be used to inform discussions with mapping groups for clarification.

All programs are encouraged as a point of practice to include equations for derivation of variances as these are helpful in reviews and to catch potential numeric mistakes. This came up during the review and was addressed by the CA team upon panel request. As a reminder, when multiplying a constant on the variance of a variable, one needs to take the square of the constant.

Provide simple plots summarizing density on a site by site basis in order to illustrate spatial variability within locations.

An analytical recommendation that is admittedly difficult to achieve would be for a workshop to examine database configuration and ways in which to make the different surveys harmonized and more easily discoverable. This applies not only to the derived data products (i.e., annotations), but also to underlying video and still frame images which can thus form the basis for additional analysis.

Encourage the use of online repositories for sharing analytical code such as GitHub.

Recommend the return of a Visual Survey Methods Workshop, such as the one held in 2014, perhaps as a standalone or as a tie-in to a national conference as a way to promote the exchange of analytical and survey methods.

ToR 4) **Evaluate model assumptions, estimates, and major sources of uncertainty.**

Review of ToR 4

California

There was a discussion of the presentation results that showed initially seemingly small CV values from the model estimates. The panel requested details of the CA team which they produced promptly the very next morning, and that illuminated a small numerical calculation error whereby the variances had not been squared. This is a great example of the value of these kinds of review meetings and of the willing responsiveness of the teams to address the concerns.

Abundance estimates at segment level are tied to bottom area which is sensitive to loss of bottom-lock (height above bed), particularly a factor where they become small segments with a few fish as this leads to very high densities. This is a known source of uncertainty and challenge to the team. Conversely, for low density areas, these measurements need to be projected to other similar substrates even if the density is very low, as the area size may still contribute to significant abundances on the aggregate.

The spatial autocorrelation analysis supports the establishment of transect lengths of 500 m as a reasonable length scale.

Overall, these estimates should be considered as a minimum index of abundance.

Some discussion and presentation was made of efforts to utilize CRFS length composition as a proxy for lengths for the ROV imagery where only a fraction of the fish counted were able to be sized. As was suggested by Dr. Field, this approach can be tricky, and it is advised to derive lengths from the ROV surveys and not use proxies which may have underlying source biases.

An additional source of uncertainty is the match or mismatch between sampling distribution both depths and substrates and species-specific attributes. This informs also the points made about species suitability to the ROV survey approach.

Oregon

Model presently assumes no interannual variation and that all habitat is captured by upscaling to rocky substrate only, which neglects the possible contribution from suboptimal habitats (soft bottom areas).

Abundance estimates at segment level are tied to bottom area, which is sensitive to loss of bottom-lock (height above bed), particularly a factor where they become small segments with a few fish as this leads to very high densities. This is a known source of uncertainty and challenge to the team.

Assumption of synoptic estimate of abundance/biomass derived from combining surveys over several years is a source of uncertainty.

The spatial autocorrelation analysis supports the establishment of transect lengths of 500 m as a reasonable length scale.

Given the uncertainties associated with the observations and analyzes, and the admittedly limited coverage areas, the estimates presented should be considered as a minimum index of abundance.

An additional source of uncertainty is the match or mismatch between sampling distribution both depths and substrates and species-specific attributes. This informs also the points made about species suitability to the ROV survey approach.

ToR 5) **When possible, provide specific suggestions for future improvements in any relevant aspects of data collection and treatment, modeling approaches and technical issues, differentiating between the short-term and longer-term time-frame.**

Review of ToR 5

Short-term Improvements

The following are suggested short-term (1-3 years) improvements that could potentially be accomplished with existing data sources:

1. Develop harmonized survey and data analysis protocols between states/regions.
2. Explore segment (OR) or full transect (CA) analysis if previously not performed.
3. Continue to maintain existing databases but improve ability to provide exchange and discoverability.
4. Search for improved very nearshore bathymetry data replacing low resolution Coastal Relief Model with Bathy/Topo LiDAR.
5. Increase the number of size measurements through greater usage of stereo camera imagery.
6. Utilize the downward looking cameras as a source of visual odometry to further constrain the noisy navigation estimates.
7. Expand survey sampling to include some non-optimal habitats.
8. Use GLM/GAM model predictions to inform survey sampling to test models.
9. Provide summaries of species suitability for the ROV based surveys.

Long-term Improvements

The following are suggested long-term (3-5+ years) improvements that could potentially be accomplished with additional data or infrastructure and operational resources:

1. Need for replacement of ROVs and addition of new sensors (i.e., INS/DVL, improved USBL, side-scan sonar, etc.).
2. The addition of a high frequency forward looking multibeam echosounder for the ROV would provide some independent constraints on the seabed geometry. A forward looking multibeam sonar would also provide additional guidance and operational safety for ROV pilots in helping to navigate the complex terrains of these rocky hard-bottom reef areas. Absent the addition of a multibeam echosounder a separate single beam altimeter for use during the nearbed surveys would be helpful, as it was noted that the existing downward altimeter is noisy and approaches blanking distance near the bed when it is most critically needed for the width estimation and for operational guidance.
3. Development and testing of Machine Learning Techniques for abundance and size estimates (see recent example French et al., 2019).
4. Establish and use similar acoustic map substrate classifications between the state programs and consider harmonizing to CMECS schema. Currently, CA and OR use different approaches and names making comparisons between habitats across state lines difficult.
5. Given difficulties in maintaining bottom lock and coverage speed, recommend efforts to improve ROV controls (making them more automated) and also for the examination of additional complementary technologies such as AUVs (for both non-trawlable and trawlable areas) and tow cameras for trawlable areas in order to increase sampling sites and coverage.
6. Quite often, out of necessity, research groups scrape together metadata and conduct their own internal data storage and indexing ,which while it may work just fine for the local research team, it may limit the ability for these hard fought data to be made useful by others in the research community. Examples of these in-house bespoke approaches include the Microsoft Access database referred to in both the ODFW and CDFW reports. Consideration should be made for integration and transfer of local databases into FGDC-compliant datasets. Of particular value moving forward is to arrange data and image structures so as to make them readily available to use and be used by image toolkits. A

great example of this is the NOAA Fisheries Strategic Initiative on Automated Image Analysis program. https://marineresearchpartners.com/nmfs_aiasi/Home.html

7. A major recommendation for both of these programs is to review and closely align the data collection, archiving, and image analysis to the tools and protocols outlined by the AIASI initiative. A benefit to the larger community image analysis efforts would come from thus having access to the derived imagery from the ROV surveys to use for further development and testing, particularly of automated machine learning algorithms for fish detection and sizing.
8. Reports mention quality control processes and R scripts for data reduction and entry. These workflows and code bases should be made available via repositories like GitHub.

ToR 6) **Prepare a Peer Review Report that summarizes the Reviewer's evaluation of the California and Oregon ROV surveys of nearshore stocks following the Terms of Reference.**

Review of ToR 6

This ToR is being met through this report, which provides updated recommendations based on the panel review meeting, updated reports, presentations and other provided review material.

ToR 7) **Provide a brief description on panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations.**

Review of ToR 7

The Review panel meeting was composed of panel members, review teams, and general attendees. Presenters were science team members of the CA and OR survey teams. The review panel consisted of Dr. Owen Hamel (chair), Dr. Ole Stratton, Dr. Alan Williams, Dr. Art Trembanis, Dr. John Field, and Bob Pacunski. A full attendee list was not recorded by this reviewer but is likely available from the meeting chair (Dr. Hamel) and/or local host (Dr. Field). Various others were in attendance as it was an open meeting and they came and went from day

to day contributing to the discussions throughout the review process. A daily attendance log was not provided nor kept as far as this reviewer is aware. Each day followed the agenda as outlined in Appendix 3, and consisted of a series of presentations and question and answer periods working through each topic. The location and logistics for the meetings was quite sufficient and more than adequately supported the meeting goals. I would recommend in future meetings that there be the opportunity for review teams to bring and demonstrate some of the ROV hardware and backend software used for the data collection and imagery data reduction components of the survey programs. The panel agenda was reasonable and daily progress was made to keep the meeting running on schedule. It is recommended for there to be more time towards the end for the future goals and recommendations topics.

Conclusions and Overall Recommendations

Overall, the platform choices and configurations are considered to be sound and represent established ROV-based technologies. Similarly, statistical treatments and approaches to expansion of the species level data into habitat-based, MPA, and regional summaries employs robust approach incorporating a range of methods from simple aggregation to “design-based” GLMs (generalized linear models) to “model-based” Generalized additive models (GAMs). In both survey programs that were examined (OR and CA), the operation teams have demonstrated a high quality of resulting scientific data.

Sampling bias associated with any survey gear can result from many factors, including noise, light, motion and pressure waves generated by the gear. Such biases should be considered for any and all gear used in the stock and habitat surveys. Gear disturbance can result in avoidance by some mobile species, leading to underestimates in density, or in the attraction of other species, resulting in an overestimation of densities. It should be stressed that the more we can make the underwater vehicles “fish like”, or stealthier, the closer we will be to accurately reflecting the relationships that exist between marine animals and their habitats. The need for

studies of bias underline the necessity of creating calibration sites that could be surveyed by all gear types. A valuable reference recommendation would be for each program to provide a summary list based on survey experiences of which species are readily exploited by this type of survey program and which species would not be amenable to this approach perhaps because of characteristics like cryptic behavior, habitat affinity, size, depth range, etc.

Machine vision refers to the capability of extracting information from digital images through the use of algorithms--either through traditional image manipulation techniques or artificial intelligence “Deep Learning” neural network strategies. The hope is that machine vision will be used to more efficiently collect accurate data on the detection, quantification, and measurement of organisms and the classification of species and seafloor substrata. While the basic quality of the image is a function of platform and image processing, it should be noted that machine vision can be challenged by the complexity of the habitat and the diversity of organisms. A major challenge with machine vision detection systems is the need for large annotated image datasets for training and testing of the algorithms and the intensive work needed by trained human annotators to build such datasets. A continued long-term recommendation for both programs is to take great care in making as many count and size annotations of species available into a database that could be pooled together for the purpose of training and testing ML (Machine Learning) techniques to help increase the throughput efficiency of detections for abundance and size.

Data management is an important consideration and one of the main areas of recommended further development. A major challenge presented by ROV systems is the massive quantity of data generated from image-based surveys. Data management is a major bottleneck in the field of underwater imagery throughout the marine science community, but by teaming up with experts in informatics and artificial intelligence, such bottlenecks can be addressed. Automation of the identification of animals and habitats is part of the solution, and can be a useful tool, depending on the level of taxonomic and/or physical identification required. There are also

open source software annotation systems available (for example: labelme from MIT or labelbox, or labelimage) that will help standardize data management and retrieval, but a single standardized workflow may not satisfy all needs. An important consideration is the need for comprehensive metadata as well as the archiving of raw data as part of any management system, so that realistic comparisons can be made over time within a survey program and for comparison to other programs. Relational database structures are recommended and the use of secure and backed up servers that can be made available to other users in the field. Each program reviewed has done a very commendable job in developing workflows and internal archive databases for their own individual uses. A short-term goal is to make sure that these are redundantly backed up and indexed in such a way as to support discoverability. A long-term goal recommendation is for state groups to partner together and with federal agencies such as NOAA to develop a shared database for further AI development and testing.

One of the issues for all the programs is the cost of developing and operating undersea imaging equipment. As seen in the reports and presentations, these systems vary from ROVs to triggered cameras to trawls, and their costs can vary tremendously requiring broad budgetary support both for acquisition and upkeep and maintenance. With the decommissioning of the submersible, DELTA, there is a need for making underwater survey equipment more available, and more frequently utilized as ROV surveys are often limited spatially and temporally. Regional programs should meet periodically to compare and share strategies and practices. Furthermore, a clear assessment and recommendation of this reviewer is to acknowledge that the end of useful life is rapidly approaching or has already passed for some of the ROV systems used throughout the West Coast surveys. Consideration should be given to efforts to replace and improve these systems. Two parallel pathways are recommended: 1) for the proliferation of smaller, lower cost systems such as the new shallow water system being used by ODFW, and 2) for the replacement of higher end and more capable systems with enhanced capabilities. Workhorse systems would benefit most greatly from improved navigation and control systems

(DVL/INS) to improve the positioning information and increase the ground capture, which is a major source of imagery loss.

The case has been made that there is a growing need for monitoring change in underwater environments as use of the ocean and its resources increases. Baseline data to measure environmental change, over all habitats and spatial and temporal scales of impact, is generally lacking. Generating needed baseline data is a strong justification for moving forward with developing undersea imaging technology. In addition, our understanding of fundamental ecosystem processes and interactions occurring on the seafloor is rudimentary (particularly with increasing depth). Therefore, the development and expanded use of undersea imaging technology for basic fisheries research is important to monitoring change.

Critique of the NMFS Review process

"The reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products."

Overall, the NMFS review process was robust and handled well. The documentation provided was useful and the format and execution of the review panel was well organized and smoothly ran. There were some long periods of no communication and it wasn't clear, to this reviewer, how the various reviewer components were organized and to be conducted. For example, it wasn't clear how the fisheries panel reviews were coordinated relative to the CIE reviews. Also, there was some miscommunication about how the fisheries committee report was to be examined relative to the CIE reviews; for instance, the fisheries committee summary report was circulated to the CIE experts while the CIE experts were still in the process of compiling their reports. This reviewer did not examine the fisheries committee report and will review it only after this independent report has been submitted. It was also not clear at the outset but was resolved ahead of the meeting what the specific role and obligations of the CIE experts was to be at the review panel meeting. It wasn't clear that there were updated reports generated by each state program (CA and OR) based on the desktop reviews by both the CIE experts and

other fisheries panel members ahead of the review panel meeting or that each state team would be making presentations. It all worked out well enough and the review panel meeting was a thorough and open exchange, but in the future it could benefit the CIE experts to have a clearer articulation of the components and obligations at each step.

Appendix 1: Bibliography of materials provided for review

Reports: The following Reports by the states of California and Oregon were updated based on the desktop review and provided describing survey and analysis approaches and preliminary results:

- Budrick L., Ryley L., and Prall M., 2020. Methods for using remotely operated vehicle survey data in assessment of nearshore groundfish stocks along the California coast. Updated Report Jan 21, 2020. California Department of Fish and Wildlife.
- Marion, S., 2020. Abundance Estimation for Nearshore Groundfish from ROV Video Surveys of Oregon's Nearshore Rocky Reefs. Oregon Department of Fish and Wildlife Marine Resources Program Newport, Oregon. Jan. 21, 2020 Updated report for Pacific Fishery Management Council, Science and Statistical Committee.

Presentations: The following presentations by the OR and CA teams were given at the review panel and made available to the reviewers:

ODFW- SCC MethRev I- ROV and sampling.pptx

ODFW- SCC MethRev III- Abundance analysis.pptx

ODFW- SCC MethRev II- Habitat relationships.pptx

ROVMethodsReview_Mprall_v2.pptx

California ROV Methods JEBv2.pptx

ROVMethodsReview_LRyleyContributionWNotes_01302020.pptx

Other Reviews, Reports and Papers: The following additional reviews, reports and papers were made available to the reviewers:

- Notes on ROV methodology review by A. Ole Shelton, Sept. 23 2019.
- Review of California and Oregon ROV programs- Bob Pacunski, Oct 1, 2019.
- Review of California and Oregon ROV programs- Aaron Berger, Sept. 24, 2019.
- Green K., Lowry, D., Yamanak, L., Proceedings of the: Visual Survey Methods Workshop April 8 & 9, 2014.

https://www.psmfc.org/tsc2/docs/TSC_Visual_Survey_Methods_Workshop_Proceedings_5_14_2014.pdf

- Pacunski R., Lowry D., Hillier L., and Blaine J., 2016. A Comparison of Groundfish Species Composition, Abundance, and Density Estimates Derived from a Scientific Bottom-Trawl and a Small Remotely-Operated Vehicle for Trawlable Habitats. Washington Department of Fish and Wildlife Fish Program Science Division. March 2016. FPT 16-03.
- Williams K., Rooper C., Levine M., De Robertis A., 2016. Using triggered cameras to determine fish behavior in rocky, untrawlable areas. Conference: Western Groundfish Conference (19th), Newport, OR, Feb 2016. https://access.afsc.noaa.gov/pubs/posters/pdfs/pKWilliams03_cameras-fish-behavior.pdf
- Olson A., Stahl J., Van Kirk K., Jaenicke M., and Meyer S., 2016. 2016 Assessment of the Demersal Shelf Rockfish Stock Complex in the Southeast Outside District of the Gulf of Alaska. https://www.fisheries.noaa.gov/resource/data/2016-assessment-demersal-shelf-rockfish-stock-complex-southeast-outside-district-gulf
- French G., M. Mackiewicz, M. Fisher, H. Holah, R. Kilburn, N. Campbell, C. Needle, 2019. Deep neural networks for analysis of fisheries surveillance video and automated monitoring of fish discards, ICES Journal of Marine Science, , fsz149, https://doi.org/10.1093/icesjms/fsz149
- The Pacific Fishery Management Council's Scientific and Statistical Committee's Terms of Reference for the Methodology Review Process for Groundfish and Coastal Pelagic Species for 2019-2020.
- Young, M. and Carr, M. H. (2015), Application of species distribution models to explain and predict the distribution, abundance and assemblage structure of nearshore temperate reef fishes. Diversity Distrib., 21: 1428-1440. doi:10.1111/ddi.12378

Appendix 2: A copy of the CIE Performance Work Statement

Performance Work Statement (PWS)
National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)
Center for Independent Experts (CIE) Program
External Independent Peer Review

Follow-Up Panel Review of Remotely Operated Vehicle (ROV) Surveys Of Nearshore Stocks - California & Oregon

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards. (http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf). Further information on the CIE program may be obtained from www.ciereviews.org.

Scope

The National Marine Fisheries Service and the Pacific Fishery Management Council is seeking a panel review to follow -up on the FY19 desk review to evaluate and review fishery independent visual survey methodologies, using remotely operate vehicles, for nearshore Groundfish species off the states of Oregon and California.

West coast nearshore groundfish stock assessments have identified the current lack of fishery-independent data sources as a research and data need (PFMC, 2017, Agenda Item E.2,

Attachment 1, September 2017). In addition, methods currently utilized in stock assessments do not explicitly account for differential biomass densities inside of no-take Marine Protected Areas (MPAs). Remotely operated vehicles (ROVs) provide a non-lethal sampling method in areas where harvest is prohibited. They also allow collection of data on overfished species and nearshore species that constrain take of healthy stocks. Because ROVs employ only non-lethal data collection methods, they avoid the need for research catch set-asides or other allocative considerations that may arise between fisheries and research sectors.

Both Oregon and California have conducted ROV surveys of rockfish in nearshore areas, focusing on rocky reef habitat, and, in California, on areas inside and outside of MPAs. In both states, resultant information includes density estimates (by transect and habitat) for various species and length data. In addition, the states have developed seafloor maps, allowing estimation of area of habitat types by depth and latitudinal breaks.

Density estimates can be developed in a number of ways, from simple extrapolations to more complex general linear models (GLMs) and generalized additive models (GAMs), including factors that may affect detection probability across sample sites. There is likely to be differential detection by species, gender and size, and by timing of survey as well.

Observed density estimates and indices of relative abundance or estimates of absolute abundance in the depth and latitudinal areas surveyed can be used in stock assessments, given appropriate accounting for selectivity and detection probability, or potentially used in management procedures. Length composition data collected by the surveys may be included in stock assessments or management procedures as well.
The general goals and objectives of Council methodology reviews are to:

1) Ensure that research surveys, data collection, data analyses and other scientific techniques in support of coastal pelagic species (CPS) and groundfish stock assessments are the best available scientific information and facilitate the use of information by the Council;
2) Provide recommendations regarding whether, and if so, how a particular methodology can be applied in future stock assessments;
3) Meet the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (MSRA) and other legal requirements;
4) Follow a detailed calendar and fulfil explicit responsibilities for all participants to produce required outcomes and reports;
5) Provide an independent external review of survey and analytical methods used to develop data to inform CPS and groundfish stock assessments;
6) Increase understanding and acceptance of CPS and groundfish research methodologies and review by all members of the Council family;
7) Ensure that methodologies not directly related to stock assessments, such as economic analyses or ecosystem-based fishery management approaches, undergo adequate peer review, as appropriate; and
8) Identify research needed to improve assessments, reviews, surveys, analyses, and fishery management in the future.

The goals and objectives specific to the review of the California and Oregon ROV survey methodologies are to:

1) Evaluate the sampling design used in recent ROV surveys conducted by the states of Oregon and California.
2) Evaluate proposed methods to develop indices or estimates of abundance for these ROV surveys, including using habitat/substrate type and Marine Protected Area designation as covariates.
3) Evaluate proposed methods to estimate size compositions of observed individuals of each species.
4) Identify potential impediments to developing independent indices or estimates of abundance using these ROV surveys and incorporating them into stock assessments.

A desk review of the ROV surveys will be held in May, 2019, which will provide initial feedback and recommendations to be considered and explored for the in-person panel review. This methodology review will lead to the development of materials and guidance for future ROV surveys and indices or estimates of abundance for those areas surveyed in Oregon and California, as well as the expansion of such methods to other areas within those states and/or within Washington State.

The specified format and contents of the individual peer review reports are found in **Annex 1**. The Terms of Reference (ToRs) for the review of ROV survey methodologies are listed in **Annex 2**. Lastly, the tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements

NMFS requires two (2) reviewers to conduct an impartial and independent peer review in accordance with the PWS, OMB guidelines, and the ToRs below. The reviewers shall have a working knowledge in visual survey techniques, survey design and analysis, and familiarity with incorporating survey information in stock assessments and have conducted the previous desk review held in FY19.

Tasks for Reviewers

1) Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contacts will send (by electronic mail or make available at an FTP site) to the CIE reviewer the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contacts will consult with the CIE on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the PWS scheduled deadlines specified herein. The CIE reviewer shall read all documents in preparation for the peer review.

Documents to be provided to the CIE reviewers prior to the methodology review include:

- Reports by the states of California and Oregon describing survey and analysis approaches and preliminary results;

- Reports of the CIE Desk Review.
- The Pacific Fishery Management Council's Scientific and Statistical Committee's Terms of Reference for the Methodology Review Process for Groundfish and Coastal Pelagic Species for 2019-2020;
- Additional supporting documents as available.
- An electronic copy of the data, the parameters, and the software used for developing population indices/estimates and compositional data.

2) Panel Review Meeting: The CIE reviewers shall conduct the independent peer review in accordance with the PWS and ToRs, and shall not serve in any other role unless specified herein. Modifications to the PWS and ToRs cannot be made during the peer review. The CIE reviewers shall actively participate in a professional and respectful manner as members of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

3) Contract Deliverables - Independent CIE Peer Review Report: The CIE reviewers shall complete an independent peer review report in accordance with the PWS. The CIE reviewer shall complete the independent peer review according to required format and content as described in **Annex 1**. The CIE reviewer shall complete the independent peer review addressing each ToR as described in **Annex 2**.

4) Other Tasks – Contribution to Summary Report: The CIE reviewers may assist the Chair of the panel review meeting with contributions to the Summary Report, based on the terms of reference of the review. The CIE reviewers are not required to reach a consensus, and should provide a brief summary of their views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

5) Deliver their reports to the Government according to the specified milestones dates.

Foreign National Security Clearance

When reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/ and

http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration- system.html. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance
The place of performance shall be at the contractor's facilities, and in Santa Cruz, California.

Period of Performance
The period of performance shall be from the time of award through March 2020. The CIE reviewer's duties shall not exceed 14 days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

Within two weeks of award	Contractor selects and confirms reviewers' participation[1]
At least two weeks prior to the panel review meeting	Contractor provides the pre-review documents to the reviewers
February 3 - 7, 2020	Each reviewer participates and conducts an independent peer review during the panel review meeting
Within two weeks after review	Contractor receives draft reports
Within two weeks of receiving draft reports	Contractor submits final reports to the Government

Applicable Performance Standards
The acceptance of the contract deliverables shall be based on three performance standards: (1) The reports shall be completed in accordance with the required formatting and content; (2) The reports shall address each ToR as specified; and (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel

[1] To ensure consistency of analytical approaches, the CIE reviewers for this panel review are the same personnel who conducted the previous CIE desk review on Remotely Operated Vehicle (ROV) Surveys of Nearshore Stocks in May 2019.

All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790). International travel is authorized for this contract. Travel is not to exceed $11,000.

Restricted or Limited Use of Data
The contractors may be required to sign and adhere to a non-disclosure agreement.

Project Contacts:
Stacey Miller
Fishery Resource, Analysis and Monitoring Division
NMFS| Northwest Fisheries Science Center
2032 SE OSU Drive | Newport, Oregon 97365
Phone: 541-867-0535
stacey.miller@noaa.gov

Owen Hamel
Fishery Resource, Analysis and Monitoring Division
NMFS| Northwest Fisheries Science Center
2725 Montlake Boulevard East | Seattle, Washington 98112
Phone: 206-697-3102
owen.hamel@noaa.gov

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent reports shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of each reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

   a. Each reviewer should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings, of the science, conclusions, and recommendations.

   b. Each reviewer should discuss their independent view on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Each reviewer should elaborate on any points raised in the Summary Report that they feel might require further clarification.

   d. The reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

e. The CIE independent reports shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer reports shall include the following appendices:

Appendix 1: Bibliography of materials provided for review
Appendix 2: A copy of the CIE Performance Work Statement
Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the proponents of ROV methodologies

Remotely Operated Vehicle (ROV) Surveys of Nearshore Stocks - California & Oregon

1. Become familiar with the reports describing the survey designs, data processing and analysis along with other pertinent information prior to review panel meeting.
2. Discuss the technical merits and deficiencies of the survey designs and analytical methods during the open review panel meeting, including revisions based upon feedback from the desk review.
3. Provide constructive suggestions for improvements.
4. Evaluate model assumptions, estimates, and major sources of uncertainty.
5. When possible, provide specific suggestions for future improvements in any relevant aspects of data collection and treatment, modeling approaches and technical issues, differentiating between the short-term and longer-term time-frame.
6. Prepare a Peer Review Report that summarizes the Reviewer's evaluation of the California and Oregon ROV surveys of nearshore stocks following the Terms of Reference.
7. Provide a brief description on panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations.

Annex 3: Tentative Agenda – Panel Review of Remotely Operated Vehicle (ROV) Surveys of Nearshore Stocks - California & Oregon

Santa Cruz, CA

February 3-7, 2020

TBD

Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Panel members included

Dr. Owen Hamel (Chair)

Dr. John Field

Dr. Ole Shelton

Dr. Alan Williams (CIE member)

Dr. Art Trembanis (CIE member)

Representatives from the individual state science teams were

California:

Dr. John Budrick, California Department of Fish and Wildlife (CDFW)

Dr. Michael Prall, California Department of Fish and Wildlife (CDFW)

Laura Ryley, California Department of Fish and Wildlife (CDFW)

Oregon:

Dr. Scott Marion, Oregon Department of Fish and Wildlife (ODFW)

A full list of meeting attendees was not recorded by this reviewer but should be available from the panel leadership team.

The Panel Review Agenda Is Attached for Reference